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APPARATUS AND METHOD FOR WIRELESS DATA TRANSMISSION

by

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CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U. S. Provisional Patent Application Serial No. 60/267,441 entitled, "Remotely Managed Automatic Dispensing Apparatus and Method", filed on February 8, 2001, and U. S. Provisional Patent Application Serial No. 60/242,898 entitled, "Remotely Managed Automatic Dispensing Apparatus and Method", filed on October 24, 2000, both of which are hereby incorporated by reference herein.

FIELD OF THE INVENTION

The present invention relates generally to the field of electronic or automatic flow control and dispensing devices and more particularly to data exchange by such devices. While the present invention is applicable for use with any number of dispensing devices, it is particularly well suited for the operation, management, and control of devices that control water flow, such as faucets, toilets, shower heads, and the like.

BACKGROUND OF THE INVENTION

Various methods have been employed to electronically control water flow through a water control device such as a faucet or spigot. Among the accepted methods is the use of an optical sensor typically employed in combination with an infrared ("IR") source or IR emitter that together with processing electronics, are used to control a solenoid valve. Generally speaking, a pulsed IR beam is reflected from an object (such as a user's hands or other body parts, for example) and sensed by a photo detector to determine whether to activate or deactivate the solenoid valve. Pulsed IR sensing remains at the forefront of sensing techniques used with these types of devices, due in part to its reasonable

performance and low cost. Automatic water flow control devices incorporating pulsed IR technology do, however, have a number of shortcomings.

A common denominator for many of the problems associated with automatically activated flow control devices, such as faucets, is the environment in which such devices are installed and operate. For instance, existing IR sensor designs generally suffer from an inability to adapt to changes in the background signal level associated with a gradual discoloration of the sink in which the faucet is mounted, a gradual degradation of the sensor lens due to the use of abrasive cleaning compounds, a gradual degradation of the IR emitter performance, among other things. Generally, existing sensors employ a fixed sensitivity threshold that is set either at the factory or by the installer (or both). When the IR sensor sensitivity is fixed, the sensors performance will inevitably degrade with environmental changes, and when the degradation causes faulty operation, a service call may be required. In some instances, the gradual degradation will go unnoticed resulting in poor performance.

In addition, IR sensors of the type made integral with the faucet often detect reflections from the water stream dispensed from the faucet. When the IR emitter is mounted behind the aerator of the faucet, as is commonly done in the art, near-IR light is reflected back from the water stream to the IR receiver causing the water to remain on, which results in a waste of water and annoyance to the user. In such a reflection scenario, the solenoid valve does not usually deactivate until the electronics of the device causes the faucet to "time out".

Inconsistent lighting conditions, as well as water and/or soap film deposits on the optical lens of the IR sensors also cause faulty operation of an automatic flow device, such as a faucet or other device activated via IR sensing. In addition, paper towels or other debris left in the sink basin can induce misleading reflections to the IR receiver.

Servicing and maintenance of presently available automatically activated flow control devices are often burdensome and time-consuming tasks. Such tasks prove particularly burdensome for maintenance personnel in settings such as public restrooms where there are a number of automatically activated flow control devices, such as faucets or toilets, in a single room. Typically to test such flow control devices, each flow control device is manually activated to enable determination of whether or not it is malfunctioning. Moreover, calibration, recalibration, and most repair work to individual units presently require maintenance personnel to at least partially disassemble or at least manually access the electronics of the units to facilitate repair work. Such tasks may be time consuming and difficult to accomplish given the location of the device electronics (usually beneath, behind or under the counter top, toilet, or other structure supporting the device). Likewise, updating or enhancing the software or electronics of these devices usually requires maintenance personnel to access the device electronics.

In addition, calibration of today's automatically activated flow control devices is often labor intensive and inefficient with respect to devices presently on the market. The low cost IR sensing devices employed in automatically activated flow control devices vary with respect to power requirements, performance, and other criteria. As a result, readings taken by these IR sensing units (such as whether a user's hands are present beneath the aerator of a faucet) are generally non-uniform from device to device and, therefore, often result in improper activation and deactivation of some devices. Similarly, as battery power for these devices decreases over time, so does the power output of the IR sensing devices. As a result, manual calibration of conventional automatically activated flow control devices is generally required during initial installation, and thereafter on a frequent basis following extended periods of use.

Unfortunately, vandalism and water damage also adversely affect the use and proper operation of automatically activated flow control devices presently available in the art. Water often travels along the wiring harness extending from the flow control device to the device's electronics causing corrosion to the parts. On occasion, vandals may

attempt to break into the electronics box associated with the device or pull the wires from either the electronics box or the faucet.

SUMMARY OF THE INVENTION

There is a need for an improved fluid dispensing system that overcomes many of the shortcomings associated with conventional automatically activated flow control devices. Such a system should provide for improved maintenance including better preventive maintenance, reduced cost of maintenance, troubleshooting help, faster transfers of information, and recording of information related to maintenance. It would further be desirable if the dispensing device consumed low power, was capable of being retrofitted into existing dispensing devices, easy to install, and low cost.

An electronically operated dispenser in accordance with the present invention is configured not only to sense for the presence of hands or other objects, but to transmit a communication signal. The automatic dispensing device utilizes a signal processor and an emitter to provide both a sensing signal and a communication signal. Transmit logic in the signal processor generates the detection signal and the communication signal and the signals may be selectively transmitted via the emitter. Accordingly, the apparatus of the present invention is configured to both detect an object in close proximity with the apparatus, and to communicate with a communication device by providing a communication signal containing information for the communication device. A preferred receiver, in accordance with the invention, is configured to both receive reflected detection signals, and to receive communication signals from the communication device. Such functionality is preferably achieved wirelessly.

In one aspect, the present invention relates to a method of remotely servicing an automatically activated flow control device. In accordance with the present invention, the method includes the steps of periodically emitting IR signals from the device indicating the identity and status of the flow control device from which the IR signals are

emitted, receiving the emitted signals with a portable communication device and processing the received signals to identify the flow control device requiring service, and indicating to a maintenance technician the identity of the device requiring service and the nature of the problem.

In another aspect the present invention is directed to a communication apparatus in an automatic dispenser for communicating data with a communication device. The apparatus includes an emitter, and logic interface with the emitter to furnish a detection signal and a communication signal to the emitter.

In yet another aspect, the present invention relates to an apparatus for automatic control of fluid flow when an object is in proximity with the apparatus and for communicating with a communication device. The apparatus includes a transmitter for transmitting a detection signal and a communication signal, a receiver for receiving a reflected detection signal, and logic configured to control fluid flow based upon the reflected detection signal.

An additional aspect of the present invention is directed to an automatic dispensing apparatus for controlling fluid flow when an object is in proximity with the apparatus and for transmitting information to a communication device. The apparatus includes logic configured to generate a detection signal and a communication signal, and a driver circuit configured to drive the signals. The apparatus further includes an emitter coupled to the driver circuit for wirelessly emitting the signals, and a receiver for receiving reflections of the detection signal where the reflections provide the basis for controlling the fluid flow.

In still a further aspect, the present invention relates to a method for detecting objects and communicating from an electronically operated dispensing device. The method includes the steps of transmitting a detection signal, detecting a reflection of the

detection signal, actuating a valve in response to the detecting step, and transmitting a communicating signal to a communication device.

The remotely managed automatic dispensing apparatus and method of the present invention results in a number of advantages over other devices and methods commonly known in the art. For example, the remotely managed automatic dispensing apparatus and method of the present invention provide for the efficient servicing and maintenance of multiple remotely managed automatic dispensing apparatuses positioned in a single room, such as a public restroom. In accordance with the invention, maintenance personnel may simply enter the room with a portable communication device and determine which if any of the remotely managed automatic dispensing apparatuses are defective, or otherwise require servicing.

Additional features and advantages of the invention will be set forth in a detailed description which follows, and in part will be readily apparent to those skilled in the art from the description or recognized by practicing the invention as described herein.

It is to be understood that both the foregoing general description and the following detailed description are merely exemplary of the invention and are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide further understanding of the invention, illustrate various embodiments of the invention, and together with the description, serve to explain the principles and operation of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention can be better understood with reference to the following drawings. The elements of the drawings are not necessarily to scale relative to each other, emphasis

instead being placed upon clearly illustrating the principles of the invention. Furthermore, like reference numerals designate corresponding parts throughout the several views.

FIG. 1 is a diagram of a conventional electronically operated automatic dispensing device.

FIG. 2 is a diagram illustrating a preferred electronically operated automatic dispensing device incorporating a portable communication device in accordance with the present invention.

FIG. 3 is a schematic diagram of an exemplary remotely managed dispensing system incorporating the dispensing apparatus depicted in **FIG. 2**.

FIGs. 4a-4f depict of exemplary control and information screens displayed by the portable communication device (PCD) depicted in **FIG. 3**.

FIG. 5 is a block diagram illustrating a the preferred elements of the control module depicted in **FIG. 2**.

FIG. 6 is a block diagram illustrating the preferred elements of the transmitting portion of the control module depicted in **FIG. 5**.

FIG. 7 is a diagram of timing relations for pulses transmitted by the dispensing apparatus of **FIG. 2.**

FIG. 8 is a block diagram illustrating the preferred elements of the receiving portion of the control module depicted in **FIG. 5**.

FIG. 9 is a diagram illustrating the location of emitter and receiver elements on the sensor module of the dispensing apparatus depicted in **FIG. 2**.

FIG. 10a-10c illustrate various views of a front-to-back mounting of photo diodes in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Because the novel and patentable features of the present invention can be shown with block and other diagrams, conventional electronic elements well known to those skilled in the art, such as transistors, amplifiers, resistors, capacitors, programmable processors, logic arrays, memories and corresponding couplings and connections of such elements are not shown. A person skilled in the art could readily understand the block diagrams illustrating embodiments of the present invention. The block diagrams show specific details that are pertinent to the present invention and do not obscure the disclosure with details that would readily be apparent to those skilled in the art.

A conventional electronically operated flow control device **20** commonly found in the art is shown in **Fig. 1.** The prior art embodiment depicted in **Fig. 1** generally includes a faucet **22**, an electronics box **24** for housing electronic components **25** and batteries **27.** The electronic components **25** are coupled to a solenoid valve **26,** which may move between an open position and a closed position in response to instructions provided by the electronic box **24**. Generally speaking, a wiring harness **30** having cables provides power and a communication link between electronics box **24,** faucet **22** and solenoid valve **26**.

As further shown in **Fig. 1**, faucet **22** of conventional electronically operated flow control device **20** typically includes an IR emitter **34** and an IR receiver **36** mounted within a collar **38** (or neck) of faucet **22**. The IR emitter **34** and the IR receiver **36**

cooperate to transmit and receive IR signals, which indicate the presence of a user's hands or other objects in the vicinity of an aerator **32**. When a signal emitted from IR emitter **34** is reflected back and received by IR receiver **36**, IR receiver **36** generates an electrical signal, referred to as a "reflection signal," that has a voltage corresponding to the signal strength of the reflected IR signal. The reflection signal is coupled through a wire in the wiring harness **30** to electronics box **24**. The electronic components **25** process the reflection signal and send a control signal through wiring harness **30** to the solenoid valve **26.** When an external object, such as a user's hands, moves into the detection range of IR emitter **34** and receiver **36**, the signal strength of the reflected signal and, therefore, the voltage of the reflection signal should be higher than normal. Thus, the electronic components **25** detect the presence of the external object. When the magnitude of the reflection signal is above a particular threshold value a control signal causes the solenoid valve to open, allowing water to flow in faucet **22**. In most conventional flow control devices **20** water flows until a timer expires or until the reflection signal is again below the threshold value indicating that the external object is no longer within the detection range of IR emitter **34** and IR receiver **36**.

Reference will now be made in detail to a preferred embodiment of the present invention, examples of which are illustrated in the accompanying drawing figures. Wherever possible, the same reference characters will be used throughout the drawings to refer to the same or like parts. An exemplary embodiment of a remotely managed automatic dispensing apparatus of the present invention is shown in **Fig. 2**, and is designated generally throughout by reference numeral **40**.

Remotely managed automatic dispensing apparatus **40** preferably includes a dispensing unit, such as a faucet **42**. Faucet **42** preferably includes a collar **38** having an emitter aperture **98** preferably covered by a signal transmissive lens, and a receiver aperture **92**, which permit signals, such as, but not limited to, IR signals to exit and enter collar **38**. Remotely managed automatic dispensing apparatus **40** further includes a control module **52**, a latching solenoid valve **56** that opens and closes in response to

signals provided by control module **52**. In the preferred embodiment, control module **52** is contained in an enclosure that incorporates an anti-vandalism bracket (not shown). Remotely managed automatic dispensing apparatus **40** may also include one or more flexible sheaths (not shown) for protecting and positioning the electrical cables **60**, which provide a communication link between a sensor module **84 (Fig. 5)** positioned within collar **38** of faucet **42** and control module **52,** and between control module **52** and latching solenoid valve **56**.

The primary purposes of the flexible sheathes are to protect the electrical wiring and to position the electrical wiring with respect to control module **52** and latching solenoid valve **56** such that flexible sheathes form one or more drip loops which are designed to capture any water inadvertently running down the electrical wiring from a leak in faucet **42**, the sink, or otherwise. A primary objective of the drip loops is to prevent water from entering the cables and reaching the electronics within the control module **52** and/or the latching solenoid valve **56**. Gravitational forces act on any water collected in the drip loops thereby preventing that water from contacting the connectors or other electronic circuitry within or adjacent to control module **52** and latching solenoid valve **56**.

Remotely managed automatic dispensing apparatus **40** also preferably includes a sensor board or sensor module **84 (Fig. 5)** that is particularly well suited for being retrofit within collar **38**. The sensor module **84** may be designed similar to or identical to conventional sensor modules employed within conventional flow control devices **20**. More specifically, the sensor module **84** may be constructed and arranged so that it may be installed in a collar having only two apertures, which is typical for conventional flow control devices **20**.

As will be described in greater detail below, remotely managed automatic dispensing apparatus **40** of the present invention is preferably designed to communicate with a portable communication device **96**. The portable communication device **96**, which

in the preferred embodiment is a reprogrammed personal digital assistant (PDA), is preferably configured to transmit and receive IR signals for establishing a communication link **97** with managed automatic dispensing apparatus **40**.

In addition to an IR emitter **86** and an IR sensor **88** such as a detection or object photo detector, sensor module **84** of the present invention preferably incorporates a data or communication IR sensor **90** such as another photo detector, for receiving communication signals from the portable communication device **96**. In one embodiment, IR sensor **88** and the communication IR sensor **90** are mounted back-to-back (not shown) on sensor module **84**. Generally speaking, photo detector lens **91** is positioned near the front of sensor board **84** for receiving light through receiver aperture **92**, while communication photo detector lens **94** faces the rear of IR sensor **88**. Transparent silicone sealant fill **93** may hold the sensors **88** and **90** securely in aligned position. Additional arrangements of IR sensors **88, 90** are possible in other embodiments. In particular it is not necessary communication IR sensor **90** to receive IR signals through the hole **99** of IR sensor **88**. For example, a side-by-side configuration for sensors **88** and **90** may be employed if desired. Further, in another embodiment a single sensor, such as IR sensor **88** may serve for detecting reflections and for receiving communication signals.

According to techniques that will be described in more detail below, control module **52**, sensor module **84** within collar **38**, and latching solenoid valve **56** may be utilized to control operation of faucet **42** and to provide information pertaining to the operational state of faucet **42**. Similarly, these components may be implemented within and utilized to control other fluid dispensing devices, such as toilets, for example.

As depicted in **Figs. 2** and **9**, sensor module **84** is preferably mounted such that IR emitter **86** is positioned behind and aligned with the transmit aperture **98** of collar **38**, while detection photo detector **88** and communication photo detector **90** are positioned behind and aligned with the receive aperture **92** of collar **38**. So arranged, the IR signals

emitted by IR emitter **86** are transmitted through transmit aperture **98**, and both the reflected signal from IR emitter **86** and the communication signal emitted by a portable communication device **96** for controlling and managing the operation of automatic dispensing apparatus **40** are received through receive aperture **92**. When desired, automatic dispensing apparatus **40** may send information to portable communication device **96** (upstream information) through transmit aperture **98**. Further, automatic dispensing apparatus **40** may receive information from portable communication device **96** (downstream information) through receive aperture **92**. Typically, most IR devices, such as the IR emitter **86** and IR detectors **88, 90,** have an integrated lens to focus infrared signals and protect the semiconductor material.

As shown in **Fig. 2**, portable communication device **96**, such as a Palm IIIe™ manufactured by 3com®, which preferably utilizes the Palm Computing Platform®, for example, may be configured to communicate with the remotely managed automatic dispensing apparatus **40** of the present invention. Generally speaking, the portable communication device **96** used to communicate with the remotely managed automatic dispensing apparatus **40** of the present invention includes an IR emitter and IR sensor that provide for exchange of data via IR signals passed through apertures **92, 98**. It will be understood by those skilled in the art, however, that other devices and particularly portable devices, such as personal digital assistants manufactured by other manufacturers, cellular telephones, pagers, portable computers, and the like may be used to communicate with the remotely managed automatic dispensing apparatus **40** of the present invention. In addition, communication signals other than IR signals may be used to transfer data between any such portable communication device and the remotely managed automatic dispensing apparatus **40** of the present invention. It is not necessary that a device communicating with the remotely managed automatic dispensing apparatus **40** be a portable device configured for IR communication. For example, one or more wires may be coupled to the remotely managed dispensing apparatus **40** to serve as a communication channel for a non-portable communication device. This being said, the preferred embodiments of the present invention will be described hereafter with reference

to the portable communication device **96** being the Palm IIIe™, but the preferred embodiments are in no way intended to be limited only to the above mentioned PDA.

Generally speaking, the present invention provides an improved maintenance and monitoring system for use in commercial facilities such as office buildings, manufacturing plants, warehouses, or the like. For example, public restrooms in an office building may benefit from such a system in that such a system may facilitate the efficient operation, management and servicing of multiple conventional automatic flow control devices throughout the building. More specifically, conventional automatic flow control devices are battery powered and therefore require battery replacement. In addition, there are typically a plurality of such devices in any given restroom within the building. As one would expect, the maintenance of such conventional dispensing devices is both time consuming and labor intensive since maintenance personnel have no efficient way of determining whether such devices require battery replacement or are otherwise defective. As a general rule, manual interaction with each device is required to make these determinations. For example, maintenance personnel position their hands beneath the aerator of each conventional automated sink to determine if the faucet is operating correctly. Troubleshooting, however, requires the time consuming steps of removing the cover of electronics box **24**, and physically checking and analyzing the circuitry and other components thereof. Accordingly, there is a need for an improved maintenance and monitoring system for commercial facilities having large numbers of automatic flow control devices.

As depicted schematically in **Fig. 3**, remotely managed automatic dispensing apparatus **40** may be a part of a remotely managed automatic dispensing system **100**. System **100** preferably includes a plurality of remotely managed automatic dispensing apparatuses $\mathbf{40_1}$, $\mathbf{40_2}$, **...**, $\mathbf{40_N}$, each having an associated dispensing unit, such as a faucet **42** or other dispensing device. The portable communication device **96** may exchange data with each of the automatic dispensing apparatuses via one or more IR communication links **97.** A site computer **102** capable of communicating with portable

communication device **96** may store information about each of the site's managed automatic dispensing devices. Optionally, one of ordinary skill in the art will recognize that system **100** may be monitored and controlled in a network environment. In a preferred embodiment, a remote server **108** may receive data relating to system **100** from PCD **96** or a site computer **102** over the Internet **110** or other network environment via any standard network connection.

System **100** of the present invention largely obviates the need for manual troubleshooting or servicing of dispensing devices. By implementing the system **100** of **Fig. 3,** maintenance personnel may enter an area, for example a restroom, containing numerous remotely managed automatic dispensing apparatuses **40** of the present invention, communicate with one or more of the apparatuses **40,** and determine which, if any, of the apparatuses are defective or otherwise require servicing based on data communicated from the one or more apparatuses **40**. In accordance with the preferred system **100** of the present invention, a failing or malfunctioning apparatus **40** may automatically discover an operational problem and broadcast an IR data signal indicating the nature of the problem. This IR data signal may indicate, for example, the serial number, location, and problem, among other things for the defective apparatus **40** in the room. Depending upon the nature of the problem associated with one or more of the apparatuses **40**, portable communication device **96** may preferably provide the maintenance person with troubleshooting information indicative of the problem. Moreover, PCD **96** may also be used to repair defective apparatuses **40**. For example, when the problem associated with a defective apparatus **40** is software related, PCD **96** may be used to transmit a software update or otherwise reprogram defective apparatus **40** by transmitting software updates via IR.

In addition, portable communication device **96** preferably includes memory for storing information such as the maintenance history and/or software update history of each device, or an installation and user's guide that may be used by maintenance personnel to install and operate new apparatuses **40**. The memory may also be used to

maintain records of data gathered or entered for each apparatus **40**, by serial number. More preferably, portable communication device **96** may be used to transmit, to one or more apparatuses **40**, commands for adjusting apparatus parameters such as IR range, and/or update the software of a given apparatus **40**, thus largely eliminating the need for maintenance personnel to open the electronics box **52** and physically access one or more of the apparatus boards. Such commands may be received by IR sensor **90** and processed by signal processor **132 (Fig. 5)**.

Information collected by portable communication device **96** may also be transferred to a site computer **102** for updating device records in stored memory of the site computer. In addition, any information transmitted by any apparatus **40** to portable communication device **96** may be sent to a web server **108** via the Internet **110** where the information may be logged and stored in a relational database, such as Microsoft Access, for device fault analysis or other research. Additionally, web server **108** may generate and deliver responses to trouble reports received from portable communication device **96** and system updates to site computer **102** via the Internet **110**.

Figs. 4a-4f depict various display screens, as viewed on portable communication device **96**, that may be used in connection with system **100** of the present invention. For example, a control panel screen **112** displays, on portable communication device **96,** a menu of selectable items for the managed automatic dispensing apparatus **40**. By way of example, but not limitation, a user may select "Information" from screen **112** and obtain information about a faucet as viewed on Information screen **114**. Adjust screen **115** provides inputs for adjusting faucet parameters, such as detection distance, flow mode, and time on. Additional example screens are shown in **Figs. 4d-4f** and provide maintenance personnel with information that will reduce troubleshooting time and time to repair. The depicted screens represent preferred examples of the types and arrangements of information that may be available to maintenance personnel on display screens provided by PCD **96**.

The block diagram of **Fig. 5** illustrates a more detailed view of control module **52** and sensor module **84**. The control module includes control logic **129** for controlling the operation of remotely managed dispensing apparatus **40**. The control logic may be implemented in hardware, software or a combination thereof. In the preferred embodiment, the control logic **129** is implemented in software and stored within a signal processor, such as, for example, a Motorola microprocessor (MC88HC908GP32CF8) having flash memory, analog-to-digital (A/D) converters and a variety of input and outputs as are described in the vendor's data sheets. When the remotely managed dispensing apparatus **40** is implemented as a faucet that dispenses fluid into a sink, the electronics of the remotely managed dispensing apparatus **40** may preferably be located in sensor module **84** contained in the collar **38** of the faucet and in control module **52,** which is typically mounted under the sink. The two modules **52, 84** may be electrically connected via cables **60 (Fig. 2)**. In addition, a cable extends from the control module **52** to a latching solenoid valve **56** that directly controls fluid flow. The control module **52** is preferably positioned in a secure enclosure while the sensing electronics or sensor module **84** is preferably positioned on a sensor board potted in collar **38** of the faucet. The potted arrangement reduces the likelihood that water will come into contact with the sensing electronics, and thus minimizes the risk of corrosion and other damage to these parts.

The signal processor **132** provides a detection signal **124** and a communication signal **125** for transmission from an IR emitter **86** in the sensor module **84**. The detection signal **124**, preferably generated by the control logic **129**, is a sequence of one or more narrow pulses. In the preferred embodiment, the pulses occur several times per second although other time intervals may be utilized in other embodiments. The detection signal is preferably sent to IR driver circuit **130** and coupled via a cable to the IR emitter that wirelessly transmits the narrow IR pulses. In the preferred embodiment, one pulse is transmitted every 250 milliseconds. The detection signal is transmitted when the automatic dispensing apparatus is in a detection mode and the communication signal is transmitted when the automatic dispensing apparatus is in a communication mode. The

managed automatic dispensing apparatus in the preferred embodiment transfers from the communication mode back to the detection mode when control logic **129** determines that all information has been exchanged.

Reflected detection signals are detected by an object photo detector **88** and are thereafter coupled to the signal processor **132** via a detection receiver **134**. Other receiver elements such as a filter or amplifier, or both may be utilized to process the reflected signals detected by the object photo detector **88**. In the detection mode, the managed automatic dispensing apparatus transmits a detection signal, receives reflected detection signals, and remains in the detection mode until there is a request to transfer to a communication mode. The communication mode request may be initiated by the portable communication device **96** as disclosed in a co-pending U.S. Patent Application filed October 23, 2001, entitled, "Data Communications System and Method For Communication Between Infrared Devices," and assigned Attorney Docket No. 00-0895.16, which is hereby incorporated herein by reference, if desired, or may be initiated by the control logic **129**. A request by the PCD **96** for switching to the communication mode preferably is initiated by a transmission of a known digital sequence from the PCD **96**. Once the known sequence is detected by the communication photo detector **90**, communicated to control logic **129** via communication receiver **136**, and verified by control logic **129**, the automatic dispensing apparatus **40** transitions to the communication mode. When the managed automatic dispensing apparatus **40** is in the communication mode, the control logic **129** transmits a communication signal to the IR emitter **86.** The communication signal may require a boost from the IR driver circuit **130** before being transmitted to the IR emitter **86**. The non limiting communication signal of the present invention may be based on the specifications described in an IR Data Association Specification and may be limited to half duplex transmission at or less than 9600 bps. Those skilled in the art could use a variety of modulation technologies to provide for information or data exchange.

When the object photo detector **88** generates a signal in response to reflected signals from an object, such as a person's hand, the signal is communicated to signal processor **132**. If the signal is greater than a threshold value, receive logic in the signal processor provides an open valve signal to a solenoid driver **57**. Solenoid driver **57** and any associated electrical components can be similar or identical to an H-bridge circuit described in U.S. patent 5,819,336, which is hereby incorporated herein by reference. The solenoid driver **57** is adapted to drive a latching solenoid valve **56** that opens in response to the open valve signal or closes in response to a close valve signal from the signal processor **132**.

The control module **52** may be powered by one or more batteries **27** or by some other suitable power source. One embodiment of the present invention incorporates four (4) AA batteries in series (around 6 volts) coupled to a voltage regulator **140** for providing a regulated voltage of three (3) volts for most of the electronics and uses six (6) volts to power the latching solenoid valve **56** and the IR emitter **86**. An audio output **150** and LED output **152** serve as troubleshooting indicators. For example, if the battery voltage is low, the LED preferably exhibits a defined on/off pattern. A battery monitor **144** serves several functions. Under no-load conditions, the battery monitor **144** determines, comparing the battery voltage with a known voltage, if the battery should be replaced. In addition, the battery monitor **144** may determine if the windings in the latching solenoid valve **56** are in an open circuit condition or in a short circuit condition by observing the battery loading characteristics. Information from the battery monitor **144** may be sent to the portable communication device **96** when the remotely managed dispensing apparatus **40** is in the communication mode. In addition, an audio signal from the audio output device **150** or a visual output from the LED output **152** may be used to notify maintenance technicians of a variety of identified problems.

Fig. 6 is a block diagram illustration of timing aspects of the automatic dispensing apparatus **40** of the present invention. The control logic **129** preferably generates a detection signal **124** when the managed automatic dispensing apparatus **40** is in the

detection mode and preferably generates a data communication signal **125**, for the upstream direction, when the managed automatic dispensing apparatus **40** is in the communication mode. The control logic **129** processor is configured to generate either the detection signal **124** or the communication signal **125**, but the control logic **129** preferably does not generate the signals simultaneously. The signal generated by the control logic **129** is sent to a digital-to-analog converter (DAC) **160** and is preferably conditioned by driver circuit **133**. An output from the driver circuit **132** is coupled over a communication link such as a wire to the IR emitter **86** in sensor module **84**. Preferably, a transmit aperture **98** in collar **38** of the dispensing device allows the infrared signal to exit from an emitter lens integrated in IR emitter **86**. Other arrangements of emitters, lenses, and apertures may provide other embodiments for transmission of infrared signals. The method of generation of the above-mentioned transmit signals is not a limitation of the present invention. In the preferred embodiment, both the pulse width and the pulse height of the detection signal and communication signal may be controlled. For example, the width of the signal preferably is controlled utilizing transistors, and the height of the signal is preferably controlled by a digital value sent to a DAC. The arrangement of the transistors and the DAC could be implemented by those skilled in the art.

Fig. 7 is a timing diagram **70** showing an event repeat time **72**, which is preferably approximately 250 milliseconds in the preferred embodiment. Within the repeat time, there is an activity time **74** of around 200 microseconds. During the activity time three samples are taken and stored within memory of the signal processor **132**. In addition the control logic **129** generates a detection signal **124**, positioned in time as shown in **Fig.** 7. Control logic **129** samples the battery condition **77**, then samples a reflection signal **78**, and finally samples the ambient condition **79** (such as room lighting). The reflection sample **78** and ambient sample are taken from object photo detector **88.** The reflection sampling occurs immediately after or as the detection signal, represented by pulse width **76** (approximately 60 microseconds), is transmitted. The ambient sampling is used to determine the light levels when no reflections occur. Those

skilled in the art would appreciate that variations of the sampling times is not a limitation on the present invention. In general, narrow pulses pull less energy from the battery providing for energy savings, but narrow pulses contain higher frequencies than wide pulses. Components that process the higher frequencies associated with the narrow pulses typically cost more and a cost/efficiency factor is a design consideration. When the repeat time is 250 milliseconds as shown in **Fig. 7**, the activity time occurs approximately four (4) times per second. Experience has shown that this frequency of activity satisfies the needs of a person using the automatic dispensing unit of the present invention. The use of the ambient sample and the reflection sample are inputs to an adjustment algorithm described in co-pending U.S. Patent Application filed October 23, 2001, entitled, "Method of Automatic Standardized Calibration for Infrared Sensing Device," assigned Attorney Docket No. 00-0895.17 and U.S. Patent Application filed October 23, 2001, entitled, "System and Method of Automatic Dynamic Calibration for Infrared Sensing Device," assigned Attorney Docket No. 00-0895.19, both of which are hereby incorporated herein by reference. In addition to the three samples described above, other samples may be taken to determine the condition of elements within the automatic dispensing apparatus **40** of the present invention. For example, samples taken when the latching solenoid valve **56** is activated may be used to determine changes in the required activation power. Changes in the activation power may give an indication of the solenoid's condition or could indicate above normal pressure in the water supply line. Neither the number of samples, type of samples, or order of samples is considered a limitation on the present invention.

Fig. 8 is a block diagram showing a preferred receiver arrangement in accordance with the preferred electronically operated dispensing apparatus of the present invention. As shown in the diagrammatic illustration a detection receiver **143** and a communication receiver **144** are shown side-by-side. The detection receiver **143** includes object photo detector **88** coupled to a detection filter **147**. The output of detection filter **147** preferably is coupled to and processed by the control logic **129**. The communication receiver **149** includes the communication photo detector **90** coupled to a decoder module **145**, the

output of which is processed by the control logic **129**. In one embodiment, the object photo detector **88** and the communication photo detector **90** may be arranged back-to-back (not shown). Various other embodiments, however, are also possible. For example, in another embodiment a single photo detector could provide signals to the detection filter and a decoder module. An arrangement of filters could also be used to separate the lower frequencies of the reflection signals from the higher frequencies of the communication signals. A more preferred embodiment will be described below with reference to **Figs. 10a-10c**. While only a single aperture is shown in **Fig. 8**, a communication lens and detection lens may be incorporated with photo detectors **88** and **90**. The arrangement and location of the aperture and lenses are not intended to limit the scope of the present invention.

Fig. 9 illustrates an exemplary top view mounting arrangement for the IR emitter **86** and the two IR detectors or photo detectors **88, 90**. When the emitter and detectors are mounted on a sensor Printed Circuit Board (PCB) of the sensor module **84**, the PCB fits within the collar **38** of the automatic dispensing apparatus **40**. In addition to the emitter and detectors, other electronic components (not shown) may reside on the PCB. As one of skill in the art will readily recognize, one or more cables preferably couple the PCB to the control module **52**.

Figs. 10a-10c illustrate a preferred front-to-back arrangement for the two IR detectors or diodes **88, 90**. Object photo diode **88** is mounted at the front of the sensor printed circuit board and the communication photo diode **90** is mounted behind and preferably offset slightly from photo diode **88**. The diodes are preferably positioned some standoff distance from one another, and secured in the positions as shown with transparent silicone sealant fill **93** as depicted in **Fig. 10c**. The object photo diode **88** preferably includes an IR transmissive aperture **99** that provides for IR signal coupling between an IR source, such as portable communication device **96**, and communication photo diode **90**. Generally speaking, the above mentioned arrangement allows IR signals to pass through aperture **99** to communication photo diode **90**, thus providing better IR

reception of data signals than the back-to-back arrangement. Although other sensors may be employed in accordance with the present invention, the preferred object photo diode **88** may be a diode identified by part number BPV23F and the communication photo detector **90** may be a diode identified by part number BPV22F, both of which are manufactured by Vishay Intertechnology, Inc.. The photo diodes **88**, **90** are preferably mounted on the sensor printed circuit board with conventional electronic components. In addition, and as indicated in **Fig. 10c**, the arrangement positioned behind a single aperture has the effect of minimizing interference from undesired light sources, such as sunlight or room lighting.

Because the automatic dispensing apparatus **40** in the described embodiment is battery powered, it may be desirable to utilize a battery savings methodology. Such a battery saving methodology is embodied when the control logic **129** configures the signal processor **132** to operate in an on mode, a wait mode, and a stop mode. When the automatic dispensing apparatus **40** is installed and functioning, the signal processor is in the on mode approximately 2.8% of the time, the stop mode nearly 97% of the time, and the wait mode for around 0.2% of the time. A low frequency clock frequency of 32.768 KHz is preferably applied to the signal processor during the stop mode allowing the signal processor to operate on about 50 microamps. When a timer, functioning in the stop mode, reaches a given value, the signal processor transitions to the on mode. During the on mode the clock frequency for the signal processor is approximately 4 MHz, requiring an operational current of about 4 milliamps for the signal processor. The wait mode requires around 1 milliamp of current, and is used for special purposes, such as providing power for operation of the control logic for the latching solenoid drivers during a transition between the on mode and the stop mode. Where the detection signal is an emitter pulse that is preferably sent 4 times per second with a pulse width of around 59 microseconds, the power requirement for the emitter **86** of the automatic dispensing apparatus **40** is significantly reduced. Conventional dispensing devices send pulses around 8 times per second with a pulse width of over 200 microseconds. In addition,

modifications to the latching solenoid valve circuits have provided an additional reduction in energy requirements.

The battery saving methodology described above allows an embodiment of the remotely managed automatic dispensing apparatus to operate on four (4) AA batteries, where each battery is capable of supplying around 2500 mAhours. Conventional dispensing devices typically require four (4) C batteries, where each battery is capable of supplying around 7100 mAhours. The reduction, of nearly 65%, in power requirements and the associated benefits of reduced cost and size represents a significant improvement over conventional dispensing devices.

In the preferred embodiment, the present invention normally operates in the detection mode, to provide the function of dispensing water. A method or procedure is provided in accordance with the present invention to transfer from the detection mode to the communication or data mode. Since the PDA communication protocol is preferably based on the IRDA specifications, it is preferable to send a known sequence to the sensor module **84** from the portable communication device **96** for at least 300 milliseconds since the operational mode for the control module **52** typically occurs for a brief amount of time every 250 milliseconds. When the control module detects the known sequence a detection mode to communication mode transition is initiated as described in the co-pending U.S. Patent Application filed, October 23, 2001, and entitled, "Data Communications System and Method for Communication Between Infrared Devices," and assigned Attorney Docket No. 00-0895.16, which was previously incorporated herein by reference.

It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the invention. For example, the remote IR detecting apparatus may be a lap top computer, a cellular telephone, a pager, or any other portable device capable of transmitting and receiving IR or near-IR signals. In addition, reflective filtering

techniques such as these disclosed in the co-pending U.S. Patent Application filed, October 23, 2001, entitled, "System and Method for Filtering Infrared," and assigned Attorney Docket No. 00-0895.15, which is hereby incorporated herein by reference, are intended to form a part of this specification. Thus it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.